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EFFECTS OF ENVIRONMENTAL POLICY ON LDC COMMODITY EXPORT EARNINGS

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July 1997

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Summary: This paper investigates the effects that environmental policies would have on commodity export earnings in developing countries. If environmental policy has non-trivial costs effects in an export sector, then export volumes fall while the world market price may go up in some cases. To what extent these effects occur has been simulated for a large number of country/commodity cases. It appears that short-term effects on export earnings are generally small, but that export earnings losses can be substantial in the longer run.

Keywords: environmental policy, commodities, exports, taxation

1. Introduction

Ample evidence is available that ecological costs of primary export production in developing countries are substantial for several commodity categories.' This source of environmental degradation causes growing concern for LDC governments. Often the environmental damage is avoidable, as alternative production methods are available to make production more environmentally sustainable. Several policy alternatives stand out to change producer behavior. Environmental values may get a commercial price by policies like direct regulation, taxes, distribution of ownership rights, or other market incentives.

Domestic environmental policy choices are compromises normally. It is seldom socially desirable to abate *all* environmental impacts of a production process, given the concomitant cost consequences and the value attached to other policy goals. Technology options, production intensity options and regional specialization options make it possible to aim for intermediary targets. In the case of export sectors, a prime government concern in LDCs is mostly that the environmental policy should not structurally diminish export earnings. Primary commodity exports persist to be a major source of foreign currency in most LDC, especially in the least-developed countries. The often-heard fear is that a too tight environmental policy for export sectors endangers overall export earnings. This paper tries to establish the validity of this concern.

Section 2 of the paper identifies the main economic factors which determine the impact of the unilateral internalization policy on export earnings. These factors are framed into a simple simulation model. Section 3 offers a first look on policy margins by assessing the relation between international market share and export share for a large set of country/commodity cases. Section 4 applies the simulation model to 14 world commodity markets. Section 5 comments on the simulation results, and the final section summarizes the conclusions.

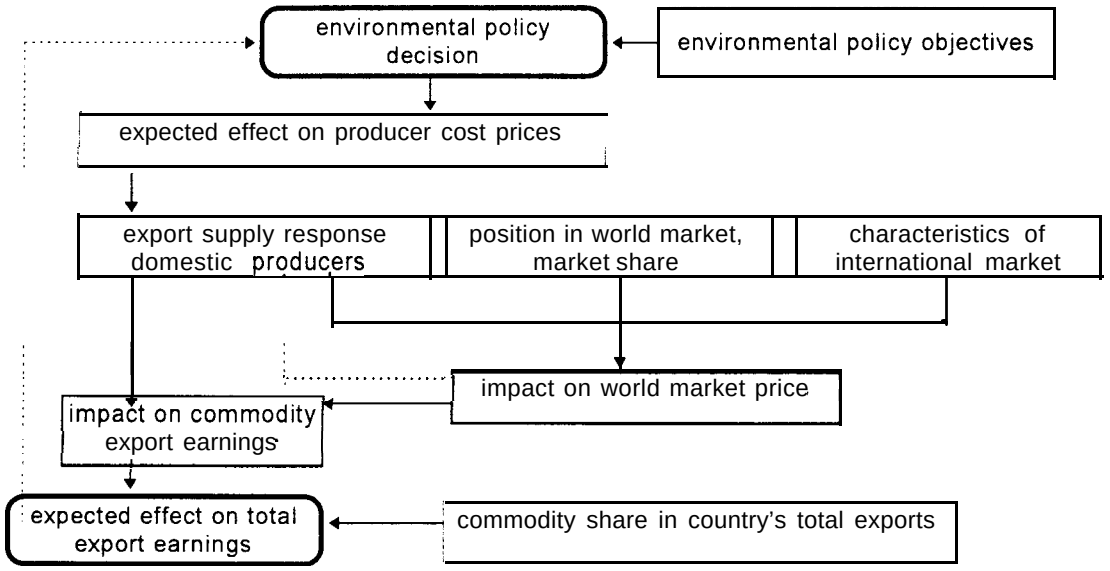
2. Domestic environmental policy and export earnings

Negative trade effects of unilateral environmental policy in small open economies are well-documented in trade literature (e.g. Walter 1975, 1974; Richardson and Mutti, 1976; Anderson and Blackhurst, 1992; Low, 1992). Public debate on trade effects of domestic policies is often framed in confusing and rather meaningless terms like 'national

[1] This literature is surveyed, inter alia, in Pearce and Warford (1993); Linnemann et al. (1993); UNCTAD (1993, 1995a, 1995b, 1995c, 1995d); Conway and Pretty (1991); Karp et al. (1995); UNEP IE/PAC (1991); Warhurst (1994).

competitiveness', Exports are not a goal in themselves, but a means towards achieving larger imports or larger domestic consumption (cf. Reinert, 1995; Krugman, 1996). Improvement of domestic environmental quality is a valuable economic achievement in itself. Trade-offs are necessary between costs and benefits of different domestic policy goals, and such trade-offs change over time. Many LDCs face foreign exchange constraints for satisfying urgent import needs and/or for servicing their foreign debts. The persistent importance of primary commodity exports as a source foreign exchange and even fiscal revenue (e.g. Chu 1990) form the reason that environmental policy decisions for these exports sectors are not taken lightheartedly.

Figure 1 ***Decision model for internalization policy with regard to an export commodity***



The expected effect of environmental measures on a country's total export earnings depends primarily on the supply reaction of producers, the characteristics of the relevant world market, and on the country's international market power. The size of the potential export loss also depends on the share of this commodity in the country's total exports. The higher this export dependency rate is, the riskier it is for a government to take unilateral internalization steps. When the export of a particular commodity represents just a minor share of the country's total export earnings, it will be much easier to give priority to environmental objectives, even if it would put this part of exports in jeopardy. Figure 1 presents a stylized decision model with the main feed back mechanisms.

The elements of Figure 1 can be framed in a formal market model. Suppose there is a world market with n countries supplying a certain commodity. Supply functions are characterized by constant price elasticity of supply:

$$S_i = a_i\, p^{\sigma_i} \qquad \text{for all country } i \in n \tag{1}$$

in which σ_i ($\sigma_i > 0$) is the price elasticity of supply of country i and a_i is a strictly positive and constant scale factor. The world market system can be split-up by only discerning the 'home' country we are interested in (indicated by suffix H) and all other suppliers, or the 'rest of the world' (indicated by suffix R).

Country block R supposedly is aggregated in such a way that it can be considered as a group with homogeneous supply. World supply (S,) is now as follows:

$$S_w = S_H + S_R \tag{2}$$

$$S_H = a_H\, p^{\sigma_H} \tag{3}$$

$$S_R = a_R\, p^{\sigma_R} \tag{4}$$

World demand is considered homogeneous and demand is characterized by constant price elasticity of demand. With liberal trade regimes, domestic commodity markets in the export countries can be considered as part of the world market, so that:

$$D = b\, p^{\delta} \tag{5}$$

in which δ ($\delta \leq 0$) is the price elasticity of demand and b is a constant and positive scale factor. For world market equilibrium to exist, it must hold that:

$$a_H\, p^{\sigma_H} + a_R\, p^{\sigma_R} = b\, p^{\delta} \tag{6}$$

The price which brings about this equilibrium is labeled p^*. For simplifying reasons, we assume that $p^* = 1$ implying that the following relation between the scale factors must hold:

$$a_H + a_R = b \tag{7}$$

Starting from equilibrium, country H introduces its internalization measures: an environmental damage tax charged to producers.[2] The policy works out as a production tax rate τ, implying that marginal revenue for producers is reduced. Country H's supply curve shifts downwards. The tax rate is a perunage of p. To characterize the supply functions before and after introduction of the policy, they are expressed as a function of the relevant producer price, i.e. $S_H\left(\frac{p^*}{1+\tau}\right)$ versus $S_H(p^*)$. The new supply becomes:

'There can be cases in which governments opt for second-best policies by taxing commodity production itself (e.g. prevalence of non-point pollution, high transaction costs for producer-oriented mternalisation measures).

$$S_H\left(\frac{p^*}{1+\tau}\right) = a_H\left(\frac{p^*}{1+\tau}\right)^{\sigma_H} \qquad (3a)$$

With altered supply conditions, the world market price also changes. The price is therefore also expressed as a function of thc tax rate in country *H,* i.e. p(r). The new world market equilibrium condition now becomes:

$$a_H\left(\frac{p(\tau)}{1+\tau}\right)^{\sigma_H} + a_R\, p(\tau)^{\sigma_R} = b\; p(z)" \qquad (6a)$$

To find out how equilibrium is affected by changes in τ and $p(\tau)$ we need this condition's total differential with respect to both variables:

$$a_H\sigma_H\left(\frac{p(\tau)}{1+\tau}\right)^{\sigma_H-1}\cdot\left[\frac{dp}{1+\tau} - \frac{p\,d\tau}{(1+\tau)^2}\right] + a_R\sigma_R\, p(\tau)^{\sigma_R-1}.dp(\tau) = b\delta\; p(\tau)^{\delta-1}.dp(\tau) \qquad (8)$$

This is hardly interpretable, but simplification is possible due to the assumption that $p^*=1$. If we further assume that τ approaches zero, than it can be derived from *(8)* how the world market price reacts on small changes in country *H*'s tax rate:[3]

$$dp = \frac{\sigma_H}{\sigma_H - \delta + \left(\frac{a_R}{a_H}\right)(\sigma_R - \delta)}\, d\tau \qquad (9)$$

The first right-hand-side factor is the tax shift factor, which will further be abbreviated as M. It indicates how much of a domestic environmental tax can be passed to the world market price. M depends entirely on supply and demand characteristics (elasticities) and on country *H*'s share in the world market, represented by the scale factors. For small changes in tax rates the result may be generalized, and the new world equilibrium price (p^{**}) can be expressed in the old equilibrium price plus the tax shifting effect:[4]

$$p^{**} = p^*\left[1 + \frac{dp}{d\tau}\cdot 1\right]\tau = p^*(1 + M\,\tau) \qquad (10)$$

All ingredients are in place now to derive how introduction of environmental tax τ affects country *H* 's export earnings. First, a direct loss of export volume occurs, because with an

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[3] The linear relation follows after intermediary finding: $a_H\sigma_H\,(dp - d\tau) + a_R\sigma_R\, dp = b\delta\, dp$ and combining this with equation (7) which holds under equilibrium..

[4] A caveat is in place here; because equation (9) was derived for the case of small tax changes in small countries. Would, however, a large export country (relative to the world market) embark on a sharp change tax increase, then the result must be treated with caution due to nonlinearities that will arise. In other conditions, equation (10) gives a good approximation of the tax's effect on prices.

initially given world market price and a price-cost margin lowered by the environmental tax, domestic producers find commodity production and exports less attractive. Crucial here is the price elasticity of domestic supply (σ_H). Reduced export supply now changes the world market price, in relation to country H's share in the world market. Domestic producers as well as foreign exporters react to the changed export price. The price effect alleviates the initial loss in export volume.[5] With export volumes expressed as a function of export prices, total change in export earnings for country H (Λ_H) amounts to:

$$\Lambda_H = \frac{p^{**}S_H\left(\frac{p^{**}}{1+\tau}\right) - p^{*}S_H(p^{*})}{p^{*}S_H(p^{*})} = \left[\frac{(1+M\tau)^{1+\sigma_H}}{(1+\tau)^{\sigma_H}} - 1\right] \qquad (11)$$

The model assumes instantaneous adaptation of the world market price to a new equilibrium value.

Numerical example. Operation of the model can be illustrated numerically with some plausible parameter values. Environmental tax measures are assumed to raise unit costs by 10 per cent and the international price elasticity of demand is set at - 0.5 which is quite normal in many international commodity markets. Since market power matters, Table 1 gives both the case of a small country, having a 3 per cent share in the world market, and the case of a large country which supplies 30 per cent of world demand.

Table 1 ***Change in export earnings (Λ_H) after introduction of an environmental tax for export producers") (per cent of change)***

	SMALL COUNTRY CASE ***($a_H = 3$; $a_R = 97$)***				***LARGE COUNTRY CASE*** ***($a_H = 30$; $a_R = 70$)***			
	$\sigma_H = 0.1$	$\sigma_H = 0.5$	$\sigma_H = 0.8$	$\sigma_H = 1.1$	$\sigma_H = 0.1$	$\sigma_H = 0.5$	$\sigma_H = 0.8$	$\sigma_H = 1.1$
$\sigma_R = 0.1$	-0.9	-4.3	-6.7	-9.0	-0.4	-1.7	-2.3	-2.9
$\sigma_R = 0.3$	-0.9	-4.4	-6.9	-9.2	-0.5	-2.2	-3.1	-3.9
$\sigma_R = 0.5$	-0.9	-4.4	-6.9	-9.3	-0.6	-2.5	-3.6	-4.6
$\sigma_R = 0.8$	-0.9	-4.5	-7.0	-9.5	-0.7	-2.9	-4.2	-5.4
$\sigma_R = 1.1$	-0.9	-4.5	-7.1	-9.6	-0.7	-3.1	-4.7	-6.0

Note: a) The following numerical assumptions are used: $p^* = 1$; $\delta = -0.5$; $\tau = 0.1$.

[5] Producers in other countries enjoy a positive pecuniary externality (Φ) of the policy pursued in country H Expressed per unit of the rest-of-the-world's initial export volume Φ amounts to: MH τ p*.

Two interesting conclusions can be drawn, The most obvious one is that small exporters suffer the largest losses in export earnings, because they hardly can pass on domestic cost increases. The second conclusion is that, for small exporters, the crucial factor determining the size of their export earnings loss is the domestic price elasticity of supply. Conversely, for a large export country, it is the *other* countries' price elasticity of supply which limits its capacity to pass on domestic cost increases to international customers.[6] Numerical simulations further showed that in the case of large exporters, the impact of a domestic environmental tax on the country's international market share is much stronger, both in absolute terms and in relative terms, compared to small exporters.

3. *Export dependency and policy margins*

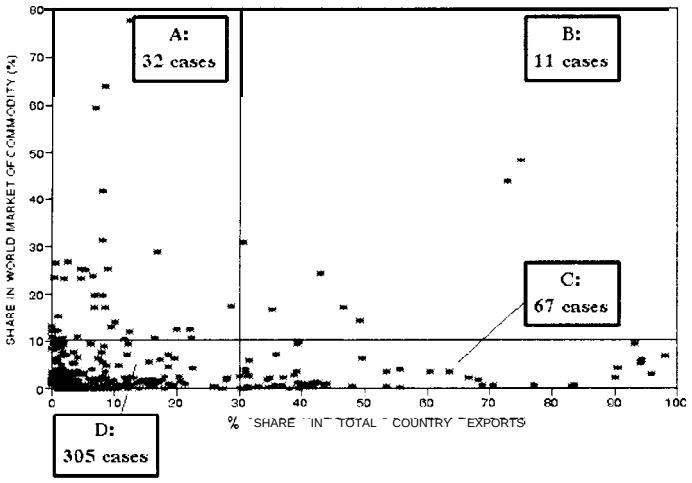
Two major factors which determine a government's policy margin in export sectors: the country's international market share and the country's export dependency on that particular commodity (cf. Figure 1). Before embarking on simulation experiments, we analyze empirical country data with regard to both factors.

From World Bank data (World Bank 1993), 415 LDC commodity export cases have been selected. The reference period is 1987-1987. Selected were those country/commodity cases where the exported primary commodity represented more than 1 per cent of the world market and/or more than 1 per cent of the country's total exports. Many LDCs have several primary export commodities that satisfy the selection criteria. Figure 2 plots the 4 15 cases with respect to international market share (%) and commodity share (%) in domestic exports.

Above some share in total country exports, the ups and downs of a particular export sector become of strategic national importance. The critical range above which this becomes valid, depends on several other factors like diversification of remaining exports, openness of the economy (exports to GDP ratio), importance of the sector for domestic income and employment generation, and presence of short-term income alternatives for producers. A plausible and cautious assumption is that these other factors are 'enveloped' quite nicely when the critical export dependency rate is put as high as 30 per cent of a country exports. With regard to the international market share, a distinction is made between countries having a small market share and those have a substantial market share. The threshold for this distinction is a bit arbitrarily set at 10 per cent of the international market. Both threshold levels have been used to subdividing all country/commodity cases into four subsets.

[6] Simulations, not shown in Table 1, show that price elasticity of demand has a relatively larger absolute impact on large country's export earnings loss.

FIG.2 SHARE OF LDC PRIMARY EXPORTS IN IN WORLD MARKET AND DOMESTIC EXPORTS



The figure demonstrates that the small country case is overwhelmingly dominant. The set of small country cases represented by quadrants C and *D* accounts for ninety per cent of the total.[7] Particularly quadrant *D* appears to be a 'gravitational black hole' for a large number of asterisks. The country/commodity cases in each of the four subsets have different characteristics with regard to policy margins:

- Subset *D*. In the 305 'small country' cases, governments cannot expect producers to recover part of domestic cost increases through a higher world market price. In terms of the model of section 2, small countries only experience the export volume effect of a unilateral environmental tax, but hardly any assuaging price effect. If domestic price elasticity of supply is low, environmental measures will not lead to important foreign exchange losses (cf. Table 1). However, with high price elasticity of supply the export loss may be substantial. Here a clear-cut trade-off results between a better environment and foreign exchange earnings, even though the latter only affect a limited portion of the country's total exports.
- Subset C. In these 67 cases, export countries find themselves in the very weakest position. They are price takers in the world market and, depending on the domestic price elasticity of supply, domestic cost increases in the export sector could endanger large sections of the country's exports.

[7] Even if the upper limit would be halved to five per cent of the world market, still 79 per cent of the cases would fall in this category.

- Subset *B* contains 11 cases.[8] The high market share puts the exporting country in a relatively good position as domestic measures will influence the world market price. However, stakes are high. Potential reactions by international competitors, importing countries, and processing industries have to be taken into consideration, as well as possibilities for inter-commodity substitution.[9]
- Subset A contains 32 'large country' cases where the exporting country has some international market power, while it is not too dependent on this particular export. With an international market share of over ten per cent, these countries are major players in the market. Several of these cases regard large countries with diversified export packages like Brazil, China and Indonesia. Their international market share guarantees that domestic 'environmental' cost increases will to some extent be recovered through a higher world market price. Reactions of other countries (traditional competitors or new entrants) can, however, be such that the initial advantage of large exporting countries is annihilated in the longer term.

Table 2 disaggregates most country/commodity cases by commodity. Its shows that in 20 commodity markets out of 29 listed commodities, one or several LDC exporters have large market shares so that they are in a good position to pass on domestic environmental taxes to their international customers through a price increase.

A potentially important factor to influence domestic policy margins is formed by competing exports from OECD countries and countries from the former USSR bloc. Price elasticities of supply in OECD countries are often higher than for most LDC exporters (cf. Annex Table 1).

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[8] This subset includes for instance Cuban sugar, Guinean bauxite, cocoa from Côte d'Ivoire and Ghana, Columbian coffee, and Chilean copper.

[9] An interesting case study stems from Malaysia where in the mid-1980s domestic palm oil mills were confronted with increasingly tough anti-water pollution measures. Malaysian palm oil exports represent over two-thirds cent of world exports. However, palm oil competes with many other edible oils, so that substitution elasticities are high. The massive effluent problems caused by the industry have been successfully reduced due to the measures. The cost of this operation have mainly been borne by Malaysia's primary producers, the farmers and estates who grow the oil palm fresh fruit bunches. These producers suffered a more than 40 per cent income loss. Compared to other segments of the Malaysian palm oil sector, primary producers had the lowest price elasticity of supply, so that most of the Polluter-Pays burden was shifted to their shoulders. In the end, hardly any of the increased production costs were passed on to foreign consumers in the form of a higher supply price (Khalid and Braden, 1993).

Table 2 *Country/commodity cases disaggregated by commodity*[a)]

Commodity	Subset A	Subset B	Subset C	Subset D	Total
Fisheries	0	0	6	34	40
Coffee	1	1	11	26	39
cotton	0	0	3	29	39
Tropical timber	1	0	3	21	25
Petroleum	0	0	17	7	24
Sugar	0	1	5	17	23
Cocoa	0	2	1	16	19
Tobacco	1	0	1	11	13
Oilseed cake & meal	2	0	0	11	13
Tea	4	0	0	8	12
Bananas	3	1	0	8	12
Beef	0	0	0	12	12
Rice	1	0	0	10	11
Copper	0	1	3	7	11
Natural rubber	3	0	0	6	9
Tin	3	0	0	6	9
Groundnuts	1	0	0	7	8
Bauxite	1	1	1	4	7
Groundnut oil	2	0	0	5	7
Maize	0	0	0	7	7
Zinc	1	0	0	6	7
Phosphate rock	2	0	1	4	7
Iron ore	1	0	2	4	7
Manganese	1	0	0	5	6
Palm oil	1	0	0	4	5
Jute	2	0	0	3	5
Nickel	0	0	0	5	5
Soybeans	0	0	0	4	4
Wool	0	0	0	4	4
TOTAL [b)]	31	7	54	291	390 [b)]

Notes: a) Subset criteria are the same as used in Figure 2; b) The number of cases does not add up to 415 because only 29 commodities are listed here. Data source: World Bank (1993)

4. *Export earnings effect simulated per commodity*

The tentative conclusions so far can be 'beefed up' by applying the partial equilibrium model of section *2* to specific commodity markets. Empirical simulations were done for 14 commodity markets on the basis of reaction parameters derived from existing econometric commodity market studies.

A distinction is made between short-term and long-term effects. What constitutes short-term or long-term may differ by commodity, depending on the time it takes before new production capacity is installed (cf. notes to tables Al and A2). Usually, short-term effects refer to the period of one or two years after introduction of the tax.[10]

The simulations calculate for all commodity/country cases the change in a country's export earnings (An of equation *l* I) after introducing a domestic environmental tax. In order to get comparable results for all country/commodity cases, some simplifying assumptions had to be made:

* *Demand:* World demand is considered homogeneous. No allowance is made for commodity varieties. Domestic commodity demand is part of world demand.
* *Supply:* Commodity supply is treated as homogeneous. When no empirical estimates on long-term price elasticity of supply were available, the long-term parameter is assumed to be twenty per cent higher (in absolute value terms) as short-term elasticity. This probably is a very conservative assumption, Long-term elasticity parameters are assumed to cover the effects of technology substitution.
* *World market equilibrium;* World market is assumed to be in equilibrium, initially. Influence of stock overhangs, strategic stockholding behavior and speculation are neglected. The equilibrium price is, in all cases, set at *l* (one). World market price is assumed to equal the price which producers receive.
* *Environmental policy:* In all cases, the 'home' country introduces a uniform environmental policy package (called 'environmental tax') leading to a ten per cent increase of marginal production costs.

Data have been drawn from different sources. Two annex tables (Al and A2) list estimates of price elasticities of supply and demand for the main LDC primary export markets. Most estimates are derived from empirical World Bank commodity market models. Scale factors

[10] For perennial crops, the long-term mostly refers to the maturity period necessary for new plantings to come into full production. For mining, the long run refers to a commodity-specific average period necessary for new mines to come into full production.

come from average actual country shares in a particular world market during the period 1985-'87, as reported in World Bank (1993).

A summary of results is presented in Table 3. The effect of introduction of the tax on export earnings is called *small* when the export earnings loss is smaller than five per cent, *large* when it is at least ten per cent, and *substantial* in all other cases. The short-term effect seems to be limited in most cases. Long-term effects are much stronger; in almost 70 per cent of the cases the impact was *substantial* or even *large.*

Table 3 ***Simulated impact of environmental policy on commodity export earnings (AH): number of country/commodity cases***

	Small impact: $\lvert\Delta_H\rvert < 5\ \%$	*Substantial impact:* $5\% \leq \lvert\Delta_H\rvert < 10\%$	*Large impact:* $\lvert\Delta_H\rvert \geq 10\ \%$
Short term	113	10	11
Long term	42	50	42

In a handful of cases, market leaders would see their short-run export earnings *increase* after introduction of the environmental policy, because reduction of their large supply causes a more than ten per cent increase in the world market price. In the longer term, supply reactions by other countries tip the balance to the negative side for large exporters as well.

Sensitivity analysis of the results showed that of all relevant model parameters, the domestic price elasticity of supply (σ_H) has by far the largest impact on the export earnings loss, both in the short run and in the long run. Price elasticity of world demand (S) and foreign supply elasticity (σ_R) have important impacts in the longer run.

Table 4 ranks the 134 country/commodity cases by commodity and by export loss intensity (number of cases with substantial and large long-term export losses divided by total number of country cases per commodity). On average, export earnings in the following commodity sectors are affected most heavily: sugar, bananas, beef, maize, and soybeans. Moderately affected are coffee, copper, tin, iron ore and jute. Least affected are countries exporting cocoa, cotton, tea and natural rubber.

Results show that domestic policy margins differ considerably by commodity export sector. For instance in a country like Honduras which exports beef and coffee, the margin for introducing an environmental tax in its coffee sector is much larger in the country's beef sector. Or, in case of Indonesia, government has much more domestic policy margin in its

natural rubber sector than in its copper sector. Charts in Annex Figure 1 picture individual country results for all 14 commodities.

Table 4 ***Classification of commodity markets by expected export earnings loss due to domestic environmentaf policy: number of countries")***

Commodity	*Short-term loss*		*Long-term loss*	
	Substantial (>5%)	***Large (>10%)***	***Substantial (>5%)***	***Large (>10 %)***
Heavily affected				
Sugar (17)	5	2	1.5	13
Bananas (9)	8	7	9	8
Beef (7)	2	1	7	5
Soybean (4)	1	0	4	4
Maize (3)	0	0	3	3
Moderately affected				
Coffee (I 7)	0	0	15	3
Copper (I 1)	0	0	10	0
Tin (9)	0	0	8	1
Iron Ore (6)	0	0	6	0
Jute (5)	2	0	4	0
Hardly affected				
Cocoa (14)	0	0	4	0
Cotton (14)	3	1	3	3
Tea (10)	0	0	2	0
Natural Rubber (8)	0	0	0	0
ALL CASES	21	11	92	42
Percentage of all 134 country/ corn. cases	16%	8%	69%	***31%***

Note: a) simulations do not consider substitution with natural or synthetic substitutes.

5. *Discussion of the results*

The behavioral parameters for these simulations have been drawn from empirical market models referring to different observation periods, using different specifications and applying different estimation procedures. This fact and the restrictiveness of the underlying assumptions imply that our simulation results can only be seen as rough indications of the export earnings impacts. There are four reasons why the simulations may actually understate the export earnings effect of a 10 per cent domestic environmental tax.

- Most of the underlying empirical studies cover observation periods which ran just to the early eighties. Since then, competition intensity in commodity markets became more intense, because of supply-side changes. Sharply deteriorating terms of trade for primary commodities, together with the need to service exponentially higher debt burdens, caused many countries to step up their export volume levels to offset the price effect." Often, IMF and World Bank loan conditionality reinforced this supply impulse (e.g. Andrew 1994; Kuster *et* al. 1996).[12]
- The simulations are strictly based on a commodity's own price elasticities of supply and demand. Some commodities can in important uses be substituted with natural or synthetic substitutes (e.g. jute, rubber, sugar, copper, tin, soybean and cotton). The simulation results in these cases give an incomplete picture of competition intensity. Export losses, certainly in the long run, are probably larger than captured in the experiments.
- A third remark regards the assumption of market equilibrium. Simulation results would be different when commodity markets are off the equilibrium path.[13] With excess demand, much more of domestic price rises can be passed on to international customers, while in case of excess supply, export earnings losses will be larger because the compensating price effect is much smaller or even absent. Because price effects are biggest when large exporters apply

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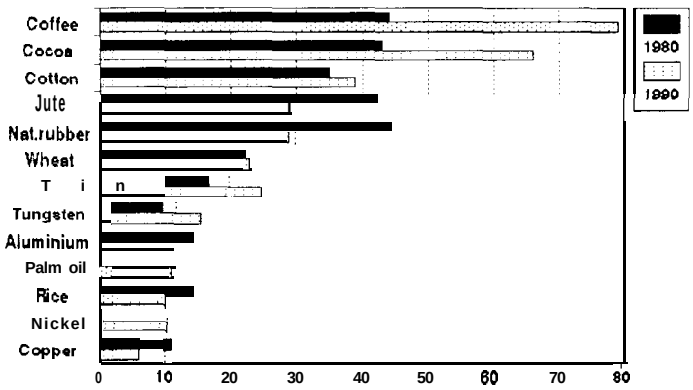
[11] "Over the last two decades, the traditional structural problems faced by commodity producers and exporters, such as price and earnings instability and relatively slow growth in demand , have been exacerbated by rapidly increasing supplies. The latter stem from increased productivity and the emergence of new and efficient producers, coupled with the inability of inefficient ones to diversify into other economic activities. This has been the case, in particular, for cocoa, vegetable oils and bauxite. For a wide range of commodities exported by developing countries, the expansion in supply has also reflected the pressure to increase exports resulting from the need to service large foreign debts" (UNCTAD 1992, p.25).

[12] It is not obvious a priori how these changes affect the price elasticity of supply in the proper sense, because the estimated price elasticity often implicitly measures the income elasticity of supply. In Annex Table 2 it appears, e.g. for cocoa, that recent studies (e.g. Lord 1991; Burger and Smit 1996) often find higher price elasticities of supply than older studies for the same markets.

[13] One could take prices to be negatively related to 'above normal' stock levels. This would add interesting dynamics to the model. The supply effects of environmental policy may interact with stock levels in several ways.

environmental taxation, the absence of price effects means in particular that export earnings losses for large exporters are underestimated in the simulations. During the 1980s, virtually all primary commodity markets have more or less permanently been in a state of excess supply (cf. Figure 3). Large international stock overhangs and idle short-term production capacity at that time would have dampened all positive price effects.

Figure 3 Stocks as a percentage of world commodity consumption, 1980/ 1990



Source: calc. from UNCTAD (1992:229-66)

- Our assumptions regarding long-term price elasticities of supply and demand have been very conservative. Intuition suggests that these parameters should be close to unity, but many of the elasticities used in the simulations (empirically estimated or set by augmenting short-term elasticities) are still well below unity. This could be a further cause why our results understating rather than overstate export earning effects.

In addition to these four reasons for understating the long-term impact, there is also a countervailing factor which could lead to lower export losses, namely technical progress stimulated by the environmental measures.

Our simulation experiments assumed a ten per cent cost price increase due to environmental policy. This is a fictive percentage, used for comparability reasons. What matters in the simulation model is the ratio of export earnings change and the change in domestic production costs due to the environmental measures (Λ_H/τ). Hence, the environmental tax rate could as well have been set at five or three per cent.

A different question is whether a ten per cent cost increase for complying with environmental policy measures is realistic. Switching to technologies which require additional investment in pollution abatement or pollution neutralization (add-on investments) can easily increase unit

cost by ten per cent or more.[14] Most estimates of 'environmental compliance costs' in OECD countries deal only with manufacturing industries, where compliance costs so far typically amount l-3 per cent of total sectoral value added (e.g. Atkinson 1996; Low 1992; Low and Yeats 1992; Tobey 1992; Jaffc et ***al.*** 1995). Pollution abatement investments as percentage of total investment in manufacturing industries can be much higher, e.g. six per cent in Australia, 16 per cent in Canada, five per cent in Germany, Sweden and The Netherlands, and seven per cent in the USA in the period 1990-92. The relative importance of pollution abatement investments was highest in primary commodity-intensive manufacturing industries, like base metal, chemicals and paper industries (UNCTAD 1994b). For primary production sectors there are hardly any international comparisons of environmental compliance costs, and only incidental cost estimates were found for LDC primary export sectors. At the average national level, available data for LDCs show that at present costs for complying with environmental policy are still quite low.[15] This does not rule out that environmental compliance costs maybe be much higher for individual export sectors. Though, with the present lack of data, the assumption of a ten percent average cost increase cannot claim an empirical fundament, it is not implausible when environmental policy objectives become more ambitious, and when existing environmental policy retorics become effectively implemented.

The simulation model assumed instantaneous market adjustment, In reality, domestic and international price and volume effects occur with a time lag rather than instantaneously. If lagged reactions would be used, this generates a dynamic, cobweb-like adjustment process, but the previous findings would not be fundamentally altered. Several world commodity markets are dominated by large trading firms with extensive trade information networks (sometimes including satellite-generated information on large crop areas), while important

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[14] See for example Blunden's estimates (1985) of water treatment costs for the non-ferrous industry, or Bardacke's report (1987) on the costs consequences of making Thai shrimp farming methods more environmentally sustainable. In the USA, the petroleum industry and pulp mills had pollution and abatement expenditures which amounted to, respectively, 15.4 and 12.4 per cent of each sector's value added in 1991 (Atkinson 1996, p. 114-5). In the US copper industry, the average costs of meeting sulphur dioxide emission standards (Clean Air Act) were estimated at $ 0.08 per pound of copper, corresponding to 45 per cent of average total smelting costs, or 10 per cent of the average price of refined copper in 1987. For the US lead industry in the same year, comparative costs were estimated at 9 • 12 per cent of the average price of refined lead, depending on whether the technology involved retrofitting of after-process installations, or a new investment project (Östensson, 1991, quoted in Warhurst 1994, p.31).

[15] Atkinson (1996, p. 122) quotes estimates of environmental compliance costs for 1987 amounting to 0.24 per cent of GDP in Thailand, and 0.38 per cent in South Korea and Indonesia, compared to 1.63 per cent of GDP in the United States in 1990. Meller at al. (1996, p.269) estimate for Chile that environmental compliance costs could reach between 1% and 2% of GDP. Chisari and Frenkel (1996, p.238) estimate that the costs to controlling industrial emissions are 0.6 per cent of total output costs in the Argentinean manufacturing sector, which would rise to 1.4 per cent of manufacturing value added if US environmental standards for industry would be implemented.

parts of outputs are traded in future markets. Dominant market agents adapt their behavior very fast in these markets. Of course, this does not apply for commodities with relatively small world trade volumes. Where production is dominated by small-scale producers, information lags can be an important element of the world market structure. While their initial responsiveness to changed producer margins may be small, lagged reactions can be such that short-term and long-term price elasticities of supply differ considerably, so that a one-shot policy measure causing environmental compliance costs for producers, may have consequences for exports that drag on for years. It would then be appropriate to consider the cumulative impact of such measures rather than short-term impacts. Empirical commodity-market research confirms that long-term price elasticities are always higher than short-term elasticities.

Our simulation analysis exclusively focused on characteristics of supply and demand behavior of countries. This tends to overlook the importance of the institutional structure of the export sector. Commodities are produced and traded by companies of various types, with interference of governments in several ways.[16] If a major share of a country's exports is produced by transnational companies, their international market power forms a favorable factor for passing on additional costs of internalization policy to consumers and customers elsewhere in the world market. Conversely, if the export sector is built on smallholder agriculture or other small producers, the scope for exploiting even a large joint supply share in the world market is much smaller, due to co-ordination problems. This problem is compounded when a limited group of large international companies dominate trade and/or processing demand of the commodity. Without these companies' consent or co-operation, it will be hard to pass on domestic environmental cost increases to the world market price.

Finally, this paper solely focused on unilateral policy measures. It was shown (Table 1) that country size matters. Hence, when several export countries are at the same time pondering on the introduction of environmental policies for a particular commodity sector, it would pay off to synchronize their policies, because of the effect on world market prices. Small countries gain most when they synchronize policies with large exporting countries.

[16] Surveys of can be found in Maizels (1992: Ch. 10); Radetzki (1990), and in a range of UNCTAD documents.

6. *Conclusions*

The paper investigated the question: "what happens to LDC export earnings when governments implement an environmental policy for a particular primary commodity export sector". The effect on foreign exchange earnings depends on supply and demand characteristics of the international market, and on the country's own share in the world market. Domestic price elasticity of supply is the most important single factor for the export earnings effect. In the longer term, also the price elasticity of demand in the world market and the price elasticity of supply in other countries become important factors.

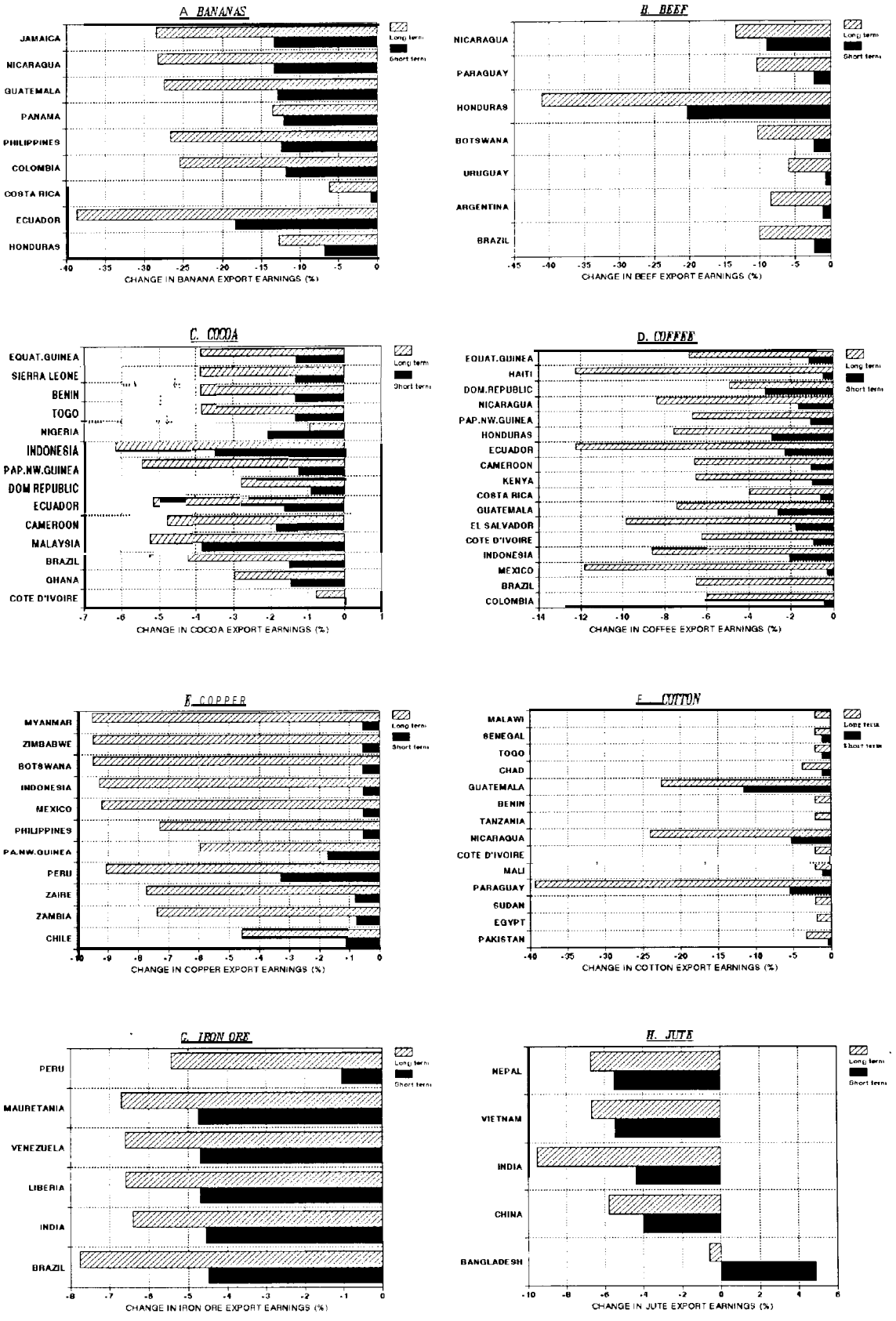
The simulation results show that in the short term, export earnings losses are relatively small in most countries. In the long-term, substantial or large export earnings losses occur in more than two-thirds of all country/commodity case. In one third of all cases, long-term losses amounted more than ten per cent. Several empirical reasons (substitution effects, debt problems, stock overhangs) are mentioned why the simulation results are probably a conservative estimate of the long-term export earnings losses.

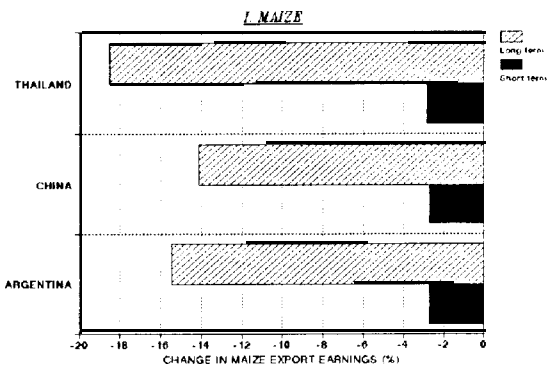
Heavily affected commodities are: sugar, bananas, beef, soybeans and maize. Losses are generally small for exports of cocoa, natural rubber, tea and cotton. Impacts differ strongly per commodity, even within one country.

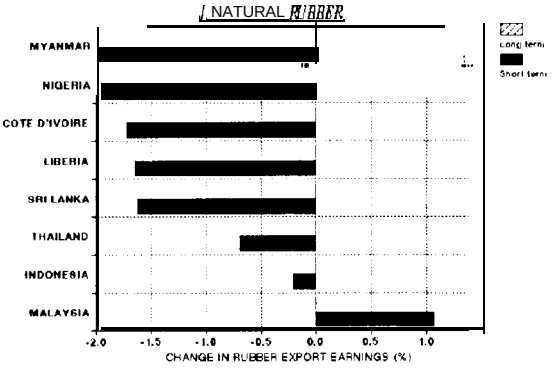
When there is a sharp trade-off between export earnings and environmental quality, governments might consider the use of compensatory measures for producers, to prevent the occurrence of a lower export supply. Such compensation is certainly warranted when an export sector generates positive externalities for the rest of the domestic economy.[17] Another auspicious way to reconcile environmental goals with the short-term necessity to maintain foreign exchange earnings levels, is to use positive incentives for producers to switch to environmentally benign production methods,

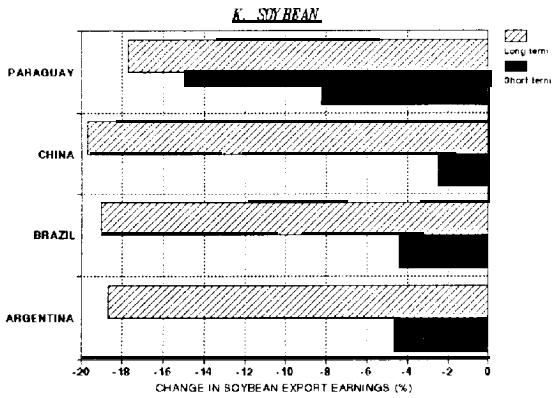
[17] More than once, governments decided to spare their export sectors and used environmental tax rebates for exported products. Such rebates are inconsistent with a Polluter-Pays policy, administratively costly, and may lead to undesired resource movements, haggling over export quantities, and even smuggling (using illegally imported commodities to qualify for tax refunds). Foreign countries could challenge such export subsidies as being at odds with international commitments in the WTO context (cf. Kox & Van der Tak 1996).

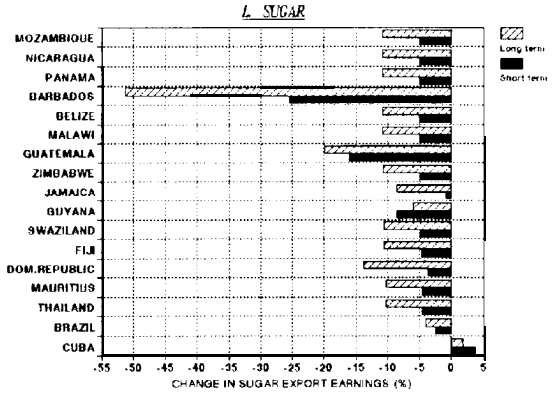
Annex Figure 1 ***Estimated effects of a ten per cent environmental tax on a country's commodity export earnings: selected commodities***

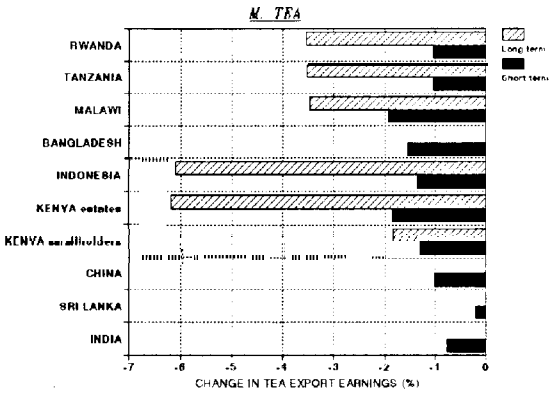


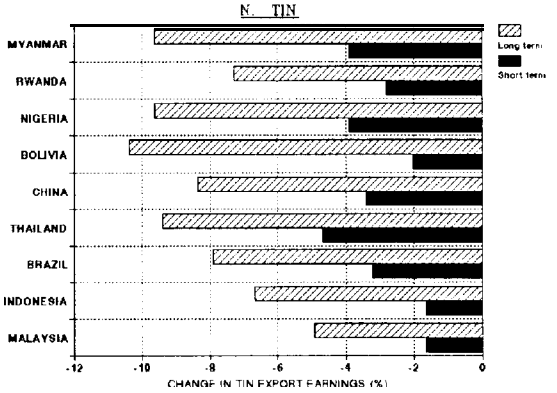

J. MAIZE
THAILAND
CHINA
ARGENTINA
-20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0
CHANGE IN MAIZE EXPORT EARNINGS (%)


J. NATURAL RUBBER
MYANMAR
NIGERIA
COTE D'IVOIRE
LIBERIA
SRI LANKA
THAILAND
INDONESIA
MALAYSIA
-2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0
CHANGE IN RUBBER EXPORT EARNINGS (%)


K. SOYBEAN
PARAGUAY
CHINA
BRAZIL
ARGENTINA
-20 -18 -16 -14 -12 -10 -8 -6 -4 -2 0
CHANGE IN SOYBEAN EXPORT EARNINGS (%)


L. SUGAR
MOZAMBIQUE
NICARAGUA
PANAMA
BARBADOS
BELIZE
MALAWI
GUATEMALA
ZIMBABWE
JAMAICA
GUYANA
SWAZILAND
FIJI
DOM.REPUBLIC
MAURITIUS
THAILAND
BRAZIL
CUBA
-55 -50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0 5
CHANGE IN SUGAR EXPORT EARNINGS (%)


M. TEA
RWANDA
TANZANIA
MALAWI
BANGLADESH
INDONESIA
KENYA estates
KENYA smallholders
CHINA
SRI LANKA
INDIA
-7 -6 -5 -4 -3 -2 -1 0
CHANGE IN TEA EXPORT EARNINGS (%)


N. TIN
MYANMAR
RWANDA
NIGERIA
BOLIVIA
CHINA
THAILAND
BRAZIL
INDONESIA
MALAYSIA
-12 -10 -8 -6 -4 -2 0
CHANGE IN TIN EXPORT EARNINGS (%)

Annex Table A1 ***Empirical estimates of price elasticities of demand for selected primary commodities***

Commodity	*Geographical coverage*	*Price elasticity of demand*		*Substitution elasticity*	*Notes*	*Source*
		short term	*long term*			
Coffee	World	-0.27				A
	World	-0.20				R
	EC	-0.07	-0.11			B
	Japan	-0.40	-0.40			B
	USA	-0.40	-0.40			B
Cocoa	**World**	-0.19				A
	World	-0.30				R
	World	-0.18				Q
	N.America	-0.12	-0.23			C
	W. Europe	-0.14	-0.21			C
	Other ind. ctrs.	-0.24	-0.69			C
Tea	World	0.06				A
	UK	-0.03				D
	UK	-0.18				E
	Rest of Eur.	-0.15				D
	USA	-0.34				D
	USA			- 0.10 (p/p_{sub})	a)	I
Banana	World	-0.40				A
	World	-0.9				R
	Japan	-1.3				R
	Germany	-2.7				R
Pineapple	World	-2.67				A
Sugar	USA,EC,Japan	-0.04				0
	USA	-0.3				R
Jute	Japan	-0.18	-0.35			F
	W. Europe	-0.11	-0.44			F
	USA	-0.82	-1.63		j)	F
Cotton	EEC-12	-0.14		+ 0.14 p_{sub}	b)	G
	USA	-0.30		+ 0.22 p_{sub}	b)	G
	World	-1.00				R
	Japan	-0.60				R
	Japan	-0.04		+ 0.04 p_{sub}		G
Refined copper	World	-0.30				K
	World	-0.50				R
	Germany			-0.24 (p/p_{sub})	c)	H
	France		-0.34	+ 0.55 p_{sub}	c)	H
	USA			- 0.32 (p/p_{sub})	c)	H
Natural rubber	World	-0.20				J
	W.Europe	-0.13	-0.46		d)	M
	India	-0.17		-0.18 $(p/p_{,,,,})$	e)	P
Tin	World	-0.50				K
	USA	-0.24 / -0.13			f)	L
	Europe	-0.11 / -0.30	-0.41		f)	L
Phosphate rock	USA,EC,Japan	-0.70				0
Tropical timber	World	-0.16			g)	N
Iron ore	World	-1.20				R

Commodity	Geographical coverage	Price elasticity of demand		Substitution elasticity	Notes	Source
		short term	long term			
	Japan	-0.60				R
	USA	-5.90				R

Notes: a) Substitute price is coffee price; b) Substitute price is polyester fibre staple price; c) Substitute price is price for aluminium; d) Refers to price elasticities of the market share of natural rubber in total demand for elastomers; e) Substitute price is for synthetic rubber; f) Short-term elasticities refer to tin demand for respectively tin-plate use and non-tin-plate use, while long-term elasticity refers to non-tinplate use; g) price elasticity for non-conifer logs; h) elasticity is for per capita consumption of chocolate product using an average retail price of chocolate; j) jute demand for primary carpet backing.

Sources: A) Islam & Subramanian (1989:228-230); B) Akiyama & Duncan (1982a:12); C) Akiyama & Duncan (1982b:14); D) Akiyama & Trivedi (1987:65); E) Ramanujam (1984); F) Thigpen & Akiyima (1986:61); G) Coleman & Thigpen (1991:33); H) Tan (1987:18); I) Chung & Ukpong (1981); J) World Bank (1981b); K) Labys (1980); L) Chhabra, Grilli & Pollak (1981:I-27); M) Grilli, Helterline & Pollak (198 1 :III-30); N) LEEC (1993); 0) Karunasekera (1984); P) Zant (1994); Q) Burger and Smit (1996); R) Lord (1991: 143-44).

Annex Table A2 ***Empirical estimates of price elasticities of supply, selected primary commodities***

Commodity	Geographical coverage	Price elasticity of supply		Price elasticity of production capacity	Notes	Source
		short term	long term			
Coffee	Brazil	+0.09	1.10		g) h)	H
	Brazil	+0.01	+0.41		d) p)	T
	Colombia	+0.07	+0.96		h) o)	H
	Colombia	+0.14	+0.99		d)	T
	Indonesia	+0.29	+1.05		h)	H
	El Salvador	+0.21	+0.56		h)	H
	El Salvador	+0.22	+1.17		d) p)	T
	Guatemala	+0.11	+0.50		h)	H
	Ecuador	+0.26	+1.43		d) p)	T
	Mexico	+0.04	+1.51		d) p)	T
	Haiti	+0.05	+1.38		d) p)	T
	Côte d'Ivoire	+0.55	+0.73		j) h)	H
	World total	+0.12	+0 74		h)	H
Cocoa	World	+0.24				F
	Malaysia	+0.20				S
	Malaysia	+0.57			q)	U
	Ghana	+0.18	+0.13		e) f)	G
	Ghana	+0.31			q)	u
	Cbte d'Ivoire	+0.26	+0.59	+0.60	e) f)	G
	Côte d'Ivoire	+0.15			q)	U
	Brazil	+0.10	+0.54	+0.62	e) f)	G
	Brazil	+0.23			q)	u
	Indonesia	+0.40			c) q)	u
	Ecuador	+0.10	+0.39	+0 62	f)	G
	Nigeria	+0.10	+0 J..	+0.11	e) f)	G
	Cameroon	+0.10	+0.59	+0.60	e) f)	G
	Cameroon	+0.24			b) q)	U

Commodity	Geographical coverage	Price elasticity of supply		Price elasticity of production capacity	Notes	Source
		short term	long term			
Tea	All LDC			0.02	a)	A
	India		0.004		a)	A
	India			+0.5		L
	Kenya			0.005	a)	A
	Kenya			+0.5		L
	Tanzania			0.115	a)	A
	India	+0.15				D/E
	Kenya smallhold.	+0.17	+0.23		b)	D
	Kenya estates	+0.25	+0.87		c)	D
	Malawi	+0.21	+0.18		b)	D
	Malawi			+1.50 – +2.0		L
	China Taiwan	+0.15			d)	D
	Sri Lanka			+1.50 – +2.0		L
Banana	World	+1.51	+3.53		d)	T
	Ecuador	+2.79	+7.17		d)	T
	Costa Rica	+0.09	+0.70		d) o)	T
	Honduras	+0.86	+1.61		d) o)	T
	Panama	+1.42	+1.57		d)	T
Rice	World	+0.50				I
Sugar	World	+0.54	+1.20		d)	T
	Brazil	+0.29	+0.46		d)	T
	Barbados	+3.15	+7.72		d) o)	T
	Jamaica	+0.10	+0.95		d)	T
	Dom. Republic	+0.43	+1.61		d)	T
Soybean	World	+0.28	+2.75			P
	Brazil	+0.56	+2.53		d)	T
	Paraguay	+0.93	+2.08		d)	T
Jute	India			+0.49 / +1.07	k)	K
	Bangladesh			+0.64	1)	K
	Thailand			+0.67	1)	K
Cotton	Latin America		0.78		n)	N
	Argentina	+0.87	+1.40			Q
	Brazil	+1.22	+3.63		d) o)	T
	Mexico	+0.59	+1.39		d)	T
	Nicaragua	+0.61	+3.03		d) o)	T
	Paraguay	+0.69	+6.16		d)	T
	Asia		0.39		n)	N
	Pakistan Punjab	+0.08				Q
	India North	+0.07				Q
	Africa		+0.22		n)	N
	Central Africa	+0.12	+0.40			Q
	Developed ctrs.		+1.80		n)	N
	Australia	+0.59	+2.46			R
	USA Southwest	+0.36	+0.95			Q
	USA total	+0.48	+0.64			R
Copper ,primary	World	+0.06				J
	Chile			+1.20 1.20		M

Commodity	Geographical coverage	Price elasticity of supply		Price elasticity of production capacity	Notes	Source
		short term	long term			
	Chile	+0.25	+0.75		d) p)	T
	Peru	+0.23		+1.10		M
	Peru	+0.41	+1.66		d) o)	T
	Zambia	+0.07		+0.93	m)	M
	Zaire	+0.07		+o. 94	m)	M
Natural rubber	Malaysia	+0.19				B
	Malaysia	+0.22				0
	Indonesia	+0.10				B
	Indonesia	+0.18				O
	Thailand	+0.24				B
	Thailand	+0.25				O
Tin	Malaysia	+0.31	+0.70			C
	Thailand	+0 60	+1.25			C
	Bolivia	+0.24	+1.34			C
	Indonesia	+0.21	+0.91			c
	Industr. countrs.	+0.30	+0.70			C
	World	+0.42	+1.07			C
	World	+0.19				J
Iron ore	World	+0.52	+1.00		d)	T
	Brazil	+0.63	+1.11		d)	T
Chromium	World	+0.20				J

Notes: a) Elasticity of mature tea area (area planted, lagged 6 years); b) long-term elasticity is for price lagged one year; c) long-term elasticity is for price lagged two years; d) only export supply; e) elasticities with respect to producer prices; f) long-term elasticity is for production lagged 9 years; g) short-run elasticity is for supply response in first two years; h) long-run elasticity is for response after ten to thirteen years; j) short-run elasticity refers to supply response lagged three years; k) price elasticities of jute acreage in short and long run, respectively; 1) price elasticities of jute acreage in short run; m) price elasticity of primary copper supply for lagged copper price; n) farmer's cotton acreage response to long-term price changes; o) short-run elasticity is export supply response after one year; p) short-run elasticity refers to export supply response which begun after more than one year; q) elasticity of cocoa production capacity utilisation with respect to real producer prices.

Sources: A) Chung & Ukpong (198 1); B) Grilli, Helterline & Pollak (1981 :III-30); C) Chhabra, Grilli & Pollak (1981:l-27); D) Akiyama & Trivedi (198753); E) Ramanujam (1984); F) Burger and Smit(1996); G) Akiyama & Duncan (1982b: 18); H) Akiyama & Duncan (1982a: 15); I) World Bank Commodity Handbook Rice (Feb. 1981); J) Labys (1980); K) Thigpen & Akiyima (1986:61); L) Akiyama & Trivedi (1987); M) Tan (1987:33); N) Thigpen (1978: 10); 0) Grilli, Helterine & Pollak (1979: 20); P) Augusto & Pollak (1981: VI-15); Q) Coleman & Thigpen (1991: 58); R) Mues & Simmons (1988);S) Khalid, Mad Nasir, Ahmad & Siti Aishah (1995: 127); T) Lord (1991: 174-5); U) Burger and Smit (1996).

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